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Effect of buffalo milk on the yield and composition of buffalo feta cheese at various processing parameters

Mansour Shakerian*, Hossein Kiani*, Mohammad-Reza Ehsani

Bioprocessing and Biodetection Lab, Department of Food science and Technology, Faculty of Agricultural Engineering and Technology, Campus of Agriculture and Natural Resources, University of Tehran, Karaj, Iran

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ABSTRACT

The aim of this study was to analyze the composition of Iranian buffalo milk and study the effect of different parameters such as fat content, acidity of milk, starter culture and temperature on the composition of buffalo feta cheese. The feta cheese yields obtained from buffalo milk were higher in comparison with the yields reported for cow milk. Higher yields were obtained when the fat content of the milk was increased. Rise in the raw milk acidity increased the yield and reduced the fat, protein and lactose loses. Thermophilic and mesophilic starter cultures exhibited better activities at 38 °C and 34 °C, respectively. Pasteurization resulted in significantly ($p < 0.05$) higher yields, but homogenization did not affect the yield notably ($p > 0.05$). The results of this study revealed that buffalo milk could be regarded as a good source for the production of feta cheese due to elevated amounts of fat, protein and Ca. The results showed that optimum conditions were needed to achieve the higher yields.

1. Introduction

The production of cheese depends on many parameters including milk composition and quality, process parameters such as time, temperature, pH, heat treatment and homogenization of milk, etc., and supplementary materials like rennet and starters. The choice of the parameters and their control, affects the composition, quality, and quantity of resulting cheese and, therefore, cheese yield and plant profit and efficiency (Lacroix, Verret, & Emmons, 1993; Lawrence, 1993; Paquet, Lacroix, & Thibault, 2000). The quality and amount of cheese produced both per volume of milk and per gram of protein in cheese milk, is important for the economic outcome of the dairy industry (Wedholm, Larsen, Lindmark-Månsson, Karlsson, & Andrén, 2006). Reductions in cheese yield and quality can lead to economic losses, and a loss of 1% in cheese yield is considered intolerable to cheese makers (Fekadu et al., 2005; Lacroix, Verret, & Emmons, 1991). Milk physico-chemical properties are functions of many other parameters such as animal genus, variety and genetics. Buffalo milk has been introduced as a good source of cheese making with higher yields and acceptable renneting properties (Bartocci, Tripaldi, & Terramoccia, 2002; Fossa, Pecorari, Sandri, Tosi, & Mariani, 1994; Tripaldi & Palocci, 2008) and a faster coagulation process (Addeo, Martin, & Ribadeaudumas, 1984; Hamdy, El-Koussy, & Abdel-Azeem, 1972) that can mostly be related to the higher susceptibility of buffalo kappa-casein to chymosin action as well as the elevated amounts of calcium and protein in the milk. Buffalo is a wide spread livestock bred all around the world, including Europe, Africa and Asia. The world population of buffalo was estimated to be more than 167 million head in 2002 and there are more than 500,000 buffalos bred in Iran (Borghese, d'Elisi, & Cuscuna, 2008; Feligini, Bonizzi, Buffoni, Cosenza, & Ramunno, 2009). In the majority of the milk-producing states, a large portion of the produced milk is used for cheese making and therefore, it is crucial to study the cheese making parameters, especially cheese yield, as affected by chemical composition of milk. Buffalo milk has been used as a source for cheese production (Bartocci et al., 2002; Fossa et al., 1994; Tripaldi & Palocci, 2008). Literature studies has shown that, compared to cow milk, the concentration of αs_2-casein and β-casein is significantly higher (around two-fold), the concentration of κ-casein is higher but close to that of cow milk, and the concentration of αs_1-casein is approximately lower in buffalo milk. Unlike cow milk that has αs_1-casein as its major casein fraction, β-casein is the major component of buffalo milk casein (Addeo, Mercier, & Ribadeau-Dumas, 1977; Feligini et al., 2009; Fox, 2003; Ganguli, Prabhakaran, & Iya, 1964). Casein micelles are generally bigger in buffalo milk (ranging between 110 and 160 μm) than micelles of cow milk with a range of 70–110 μm (Oommen & Ganguli, 2000). The micelles of buffalo milk are also richer in calcium and phosphate. The percentage of whey proteins from total buffalo milk proteins is lower compared to the same value for

* Corresponding authors.
E-mail addresses: mshakeriandez@gmail.com (M. Shakerian), hokiani@ut.ac.ir (H. Kiani).

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bovine milk but the concentration of whey proteins is almost equal for buffalo and bovine milk with a minor difference (higher α-lactalbumin and lower β-lactoglobulin contents in buffalo milk).

There have been several studies to evaluate the effect of milk source and chemical composition of milk on the cheese making yield. Some researchers have studied the effect of milk protein and fat content (Verdier-Metz, Coulon, & Pradel, 2001; Verdier-Metz, Coulon, Pradel, Viallon, & Berdagué, 1998), kappa-casein content of milk at a constant protein concentration (Bittante, Penasa, & Cecchinato, 2012; Bonfatti et al., 2011; Zambrano Burbano, Eraso Cabrera, Solarte Portilla, & Rosero Galindo, 2010), Fourier transform infrared spectroscopy (FTIR) spectra of milk (Bittante et al., 2012; Cecchinato et al., 2013), and milk coagulation properties (Ikonen, Morri, Tyrisevä, Ruottinen, & Ojala, 2004; Ikonen, Ruottinen, & Syväoja, 2008; Malacarne et al., 2006) on the yield and characteristics of cheese and have found correlations between the studied parameters and cheese properties. Brown, Law, and Knight (1995); Fekadu et al. (2005) studied the yield of goat's cheese and revealed that cheese properties are affected by breed, physiological state and nutrition of the animal and the quality of the milk used for cheese making, and, therefore it is necessary to optimize cheese making methods for different compositions to increase milk nutrient recoveries and thus increase cheese yield. A number of researchers studied the variation of cow's milk composition during lactation and evaluated the cheese yield caused by this variation (Bittante et al., 2012; Samoré et al., 2010; Samorè, Canavesi, Rossoni, & Bagnato, 2012; Summer et al., 2003). Their results indicated that fat and protein content have high genetic correlations with percentage cheese yields, but these values were significantly lower than 100%, showing that other parameter can also affect cheese yield and the ability of the coagulum to retain the highest possible amount of protein, fat, and water (Bittante et al., 2012; A. Samoré et al., 2010; A.B. Samorè et al., 2012; Summer et al., 2003). Processing parameters have also been proved to significantly affect the yield of cheese (Cipolat-Gotet, Cecchinato, De Marchi, & Bittante, 2013; Cipolat-Gotet, Cecchinato, De Marchi, Penasa, & Bittante, 2012; Fagan, Castillo, Payne, O'Donnell, & O'Callaghan, 2007).

The aims of this study were to analyze the general properties of Iranian buffalo milk and to investigate the effect of some processing factors like raw milk acidity, the type of starter culture, incubation temperature, homogenization and pasteurization on the yield and general properties of feta cheese produced from buffalo milk.

2. Materials and methods

2.1. Buffalo milk preparation and analysis methods

Buffalo milk was collected from local smallholders of Shoosh countryside (Khuzestan province, Southern west of Iran). The milk was then transferred to Khuzestan Dairy Pegah Co. for evaluation, storage and processing. The density of the milk was measured by a lactodensimeter (Witeg, Wertheim, Germany, Germany) at 15 °C. The fat content was determined using the Gerber method (Navvabpour, Barazandegan, & Hakimian, 1993). Total nitrogen content was analyzed by the Kjeldal approach and the conversion factor of 6.4 was used to estimate the total protein content. The total solids (TS) content of the milk was determined by evaporation of ~1 g sample on a boiling bath, followed by oven-drying at 102 °C until constant weight was attained (Anonymous, 1970). A Digimatic milk Cryoscope 4D3 (Advanced Instruments, Norwood, MA, USA) was used to determine the freezing point. A Metrohm 744 digital pH meter (Metrohm, Herisau, Switzerland) was employed to measure the pH of the samples. Cheese acidity and TS content were measured according to the official standard methods of Iran (Hassanpour & Khaknejdad, 2007; NiAkan & Taghizadeh, 2002). Cheese fat content was determined by the Gereber method. A Milko-scan S50 (Foss, Hillerød, Denmark) instrument was used to measure the fat, protein, lactose, and fat free TS of the whey produced from cheese making process. An Alfa-Laval SH30 homogenizer (Alfa-Laval, Lund, Sweden) was applied for homogenization purposes. The Calcium content of the buffalo milk samples was determined using an atomic absorption spectrometer (model 3110, PerkinElmer, Massachusetts, USA). Measurements were performed at the wavelength of 422.7 nm after digestion of the organic matter with Chloroacetic acid. Na and K assessments were performed using an ElectroSelenium Ltd 100 flame photometer apparatus (Evans Electroselenium Ltd., Halstead, England) after conversion of the samples to their ashes. The concentration of phosphorous was determined by spectrophotometry (Pharmacia Novaspec 11, GE Healthcare, Uppsala, Sweden).

2.2. Cheese making procedure and experiments for cheese making evaluation

White brined Feta cheese was produced from buffalo milk. Four different batches obtained from the same livestock were mixed and used for cheese making. The milk was divided into four replications for each treatment. The general process for the production of Feta cheese from buffalo milk is shown in Fig. 1. The stages that are shown by dashed lines were subject to changes or adjustments in our studies. In three separate experimental setups, the effect of different variables on the cheese making parameters was studied. As will be discussed in the coming sections, the first set of experiments evaluated the influence of the initial acidity of raw full-fat milk. In the second experimental setup the effect of starter culture type, incubation temperature and acidity increase level during incubation was examined. The last experimental setup was designed for the analysis of the effect of homogenization and pasteurization. The measured parameters included the cheese yield, acidity and fat content as well as chemical characteristics of whey.

2.3. Experiment 1: The effect of natural acidity of raw full fat buffalo

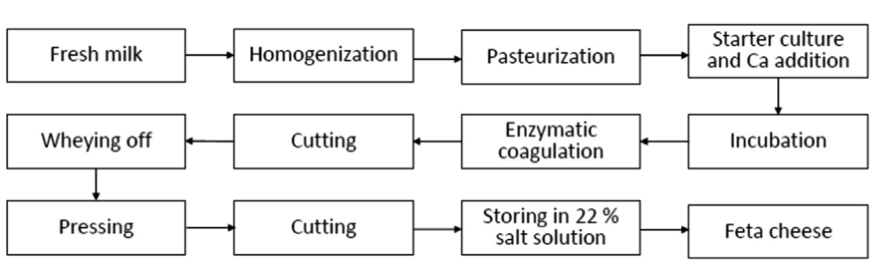

Fig. 1. : Schematic of Feta cheese production process.